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ANALYSIS OF GLASS CHARACTERISTICS USING OPTICAL AND ELECTROPHYSICAL METHODS

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Glass parameters are studied using the methods of electron-probe microanalysis, Auger electron ellipsometry, and spectrophotometry. The optical and color parameters of tinted glasses are determined, and the state of their surface is studied.

In the course of glass production, in particular, tinted glass production, analysis of its optical parameters, defects, and surface state makes it possible to correct the technology for the purpose of attaining the required quality level.

There are numerous optical and electrophysical methods for investigation of glass. Thus, the spectrophotometric method allows recording of glass transmission spectra and calculation of color parameters based on them (color coordinates, dominating wavelength, color purity). Use of infrared spectrophotometry in the reflecting mode makes it possible to evaluate the concentration of SiO_2 based on peaks of stretching ($1100\ cm^{-1}$) and deformation ($500\ cm^{-1}$) vibrations of the Si – O bond. Moreover, in the case of the presence of an organic film on a glass surface, it composition can be identified.

Electron-probe microanalysis and Auger electron electroscopy make it possible to perform elemental analysis of the glass composition, films on the glass surface, and extraneous inclusions in the glass. The ellipsometry provides for determination of the thickness, refractive index, and extinction coefficient of thin transparent and semitransparent films on a glass surface, as well as the reflection index for glass of various compositions obtained by various technological procedures.

The present paper describes results of a study of the characteristics of glass produced on the Saratov Institute of Glass production line, involving the indicated methods of analysis.

The glass color characteristics were investigated on a Specord 40M spectrophotometer. The results were presented in the form of the glass transmission spectrum and color coordinates calculated according to a special program for different emission sources (A, B, C). The color triangle was used to determine the dominant wavelength and the color purity.

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The color characteristics of currently produced glasses are measured periodically. Analysis of color characteristics is especially important in converting the production process to another type of glass. Using the magnitude of absorption peaks of additives introduced into the glass, their concentration can be adjusted in order to obtain the required color characteristics.

A color chart has been made for 42 standard glasses developed at the Saratov Institute of Glass (SIG). It was found that their color characteristics encompass virtually the entire range of the visible transmission spectrum. The dominant wavelength varies from 410 to 620 nm with a step of several nanometers. Thus, using the color chart, it is possible to reproduce technological procedures for producing tinted glass with any shade of the visible spectral range. Table 1 gives the color coordinates of typical glasses produced on the SIG production line.

Quantitative microprobe analysis [1] was used to determine the chemical composition of glass, as well as the composition of glass inclusions. The method consists in correlation of typical x-ray radiation of the analyzed element with the radiation intensity of a reference sample with a known composition representing the same element. The x-ray spectra were measured on a Superprobe 733 electron-probe microanalyzer.

The results of the glass-composition measurements agree well with chemical-analysis data.

TABLE 1

Glass	Color coordinates	
	X	Y
Bronze 1 (with cobalt)	0.329	0.333
Bronze 2 (without cobalt)	0.329	0.336
Dark bronze	0.343	0.339

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The method makes it possible to determine the tin content on a glass surface in contact with a tin melt in a glass-melting tank. Its level is 1.5 – 2.0%. It is also possible to measure the tin concentration profile using glass etching by layers.

The ellipsometric method [2] was used to analyze the state of a glass surface before deposition of iron and titanium and to determine the thickness of films obtained under various technological conditions. The method is based on analysis of the polarization variation of monochromatic, elliptically polarized light reflected from the analyzed surface. The polarization variation is related to the thickness, refractive index, and extinction coefficient of the film on the glass surface, as well as the optical characteristics of the glass.

A glass surface was analyzed by an AÉM-2 ellipsometric laser microscope (monochromatic-radiation wavelength 6328 Å). It was found that when the technological conditions of glass treatment before deposition of metallic films are observed, the ellipsometric parameters of the glass surface correspond to the parameters of the pure glass. In the case of low adhesion of the metallic coating to the glass surface, a thin organic film 20 – 30 Å thick was identified on the glass surface. The thickness of the iron and titanium films amounted to 50 – 300 Å depending on the technological conditions.

An attempt was made to identify the composition of impurities on a glass surface before film deposition, using the method of IR spectrometry in the reflection mode on a Specord 80M spectrophotometer. However, the sensitivity of the method did not allow for identification of the composition of films 10 – 20 nm thick. Films of this thickness have to be analyzed using an instrument with total internal reflection, which significantly increases the method sensitivity.

Thus, optical and electrophysical methods make it possible to determine the optical and color parameters of tinted glass and its composition and inclusions and to investigate the state of the glass surface.

REFERENCES

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